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The Improvement of Ethnic Farmers' Livelihoods by Agroforestry Practices in The Madhupur Garh, Bangladesh

J. Rana, N. Hossain, N.E.K. Alam, K. K. Islam

Department of Agroforestry, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

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Abstract— *In Bangladesh, agroforestry has significantly replaced traditional forest management with more people-centered strategies due to the country's shrinking forestland. Products from agroforestry production methods help millions of small farmers around the world meet their basic necessities and improve their standard of living. In Bangladesh, the advantages of agroforestry systems and their tactics for promoting livelihood success are sometimes not consistently acknowledged. The study's goal was to explore viable local agroforestry practices and to ascertain how they might affect the development of the livelihoods and means of subsistence of ethnic farmers in Bangladesh's Madhupur Garh. The study identified five main types of local potential agroforestry practices, which are Acacia-Pineapple-Papaya, Acacia-Pineapple-Ginger, Acacia-Pineapple-Turmeric, Mango-Pineapple-Papaya, and Acacia Pineapple-Aroid based agroforestry that are cultivated throughout the Madhupur Garh, using a variety of qualitative and quantitative data collection techniques. Additionally, these agroforestry techniques have concurrently improved the human, social, financial, natural, and physical capital of ethnic farmers. This suggests that the area's prospective agroforestry techniques have greatly improved farmers' agroforestry production knowledge and skills, as well as their knowledge of and access to educational institutions, home infrastructures, healthcare facilities, local road systems, and social networks. As a result, the study came to the conclusion that locally viable agroforestry techniques like Acacia-Pineapple-Aroid had improved the livelihood of the ethnic farmers, which in turn helped the community as a whole.*

Keywords— ***Livelihood capitals, Agroforestry, Income Generation, Ethnic Community, Bangladesh.***

I. INTRODUCTION

The need for a more productive and sustainable use of the land becomes more essential as the global population grows. In 2011, there were more over 7 billion people on Earth, and by the middle of the century, that number is projected to rise to 9.3 billion. By 2050, production will need to expand by almost 60% just to keep up with demand. These statistics, along with the ongoing issues resulting from past and present unsustainable land-use practices, provide the argument for altering how we manage lands and produce agricultural and forestry products. To meet their daily needs and earn money, rural communities all throughout the developing world use food, fuel, fodder, building supplies, medicines, and other items from forests and other untamed natural areas (Bayron and Arnold, 1999; FAO, 2008; Kaimowitz, 2003).

Calculating the relative and absolute value of environmental income's contribution to overall income. In order to develop effective development and conservation strategies, portfolios are crucial for understanding rural people's livelihoods, the extent and causes of poverty and inequality, the welfare implications of resource degradation, and more (Angelsen and Wunder, 2003; Jagger et al., 2012). Only 17.08% (2.52 million hectares) of the country's territory is forested, with 10.7% of that area made up of 13 wildlife sanctuaries (223,648.68 ha) and 15 protected national parks (45,312.65 ha). (GOB,2011). The Forest Act of the 1950s, which prohibited private ownership of woods, marked the

beginning of Bangladesh's history of protected areas. Due to this Act, the Forest Department gained responsibility over all-natural forests, including Sal forests. When the Forest Department gained authority of the woodlands, it designated the Madhupur Sal forest as a protected area in 1962 (Sarker and Ahmed, 2008). The Madhupur Sal forest has historically supported a vast and diverse range of flora and fauna, but it is currently one of Bangladesh's most endangered ecosystems. Since the dawn of time, two significant ethnic minorities—the Garo and the Koch—have made use of these forests (Gain, 2002 and 2005); the Sal forests were crucial to their way of life (Gain, 2007). According to recent figures, the 21 villages that make up the Madhupur Sal forest (also known locally as Madhupur Garh) are home to roughly 50,000 households that depend on the forest, including 20,000 ethnic minorities (Islam et al., 2013).

Agroforestry techniques that increase agricultural productivity and profitability are intimately tied to ethnic minorities. Through the integration of trees in farms, agroforestry is a dynamic ecologically based, natural resource management method that increases the social, economic, and environmental advantages for all land users. Agroforestry can sustainably offer a good ecological foundation for higher agricultural and animal yield, more reliable economic return, and a wider variety of social advantages. Madhupur, a primary Sal (Shorea robusta) forest, is governed by the Bangladeshi Forest Department. The common fruit trees in the Madhupur Sal Forest include the Mango (Mangifera indica), Jackfruit (Artocarpus heterophyllus), Papaya tree (Carica papaya), Litchi (Litchi chinensis), Banna tree (Musa cavendish), and Sal (Shorea robusta), while the common trees include Akasmoni and Sal. They also co-cultivated with plants including ginger (Zingiber officinale), pineapple (Ananus Sativa), mistikumra (Cucurbita moschata), lamba kachu (Colocasia esculenta var. lypica), turmeric (Curcuma domestica), casava, and others. Once more, we can obtain fruits, fuel, timber, fodder, fruits, and other things from trees. As a result, ethnic communities in Madhupur Garh, a region of the country that has experienced significant deforestation, engage in a variety of agroforestry methods that have an impact on farmers' income and quality of life as a whole and should be identified.

II. THEORETICAL FRAMEWORK

The DFID Sustainable Livelihood framework was employed as the study's theoretical foundation. The DFID's framework for sustainable livelihoods is centered on the fundamental dynamics of livelihoods and how people are represented on a collection of assets or capital that serves as the basis for their livelihoods (Carney 1998; Hussein and Nelson 1998). These capitals are represented by the following in the DFID framework for sustainable livelihoods: Human capital (skills, knowledge, the ability to work, good health), Social capital (relationships based on reciprocity and trust, networks, group membership), Physical capital (basic transportation and communication infrastructure, housing, water and sanitation system), Natural capital (land, forests, air, water, wildlife, biodiversity), and Financial capital (moneta).The creation of livelihood assets and capital is the major way that Bangladesh's agroforestry systems improve the livelihood of rural farmers. The building blocks of a livelihood are assets, and a variety of assets are needed to provide beneficial effects on a livelihood (Islam and Sato 2012, 2013; Warner 2003). Strong improvement can be defined as development in all five capital cities, but poor improvement in livelihoods can be described as development in only certain of the cities that make up for any fall in other cities (Das 2009). In the context of agroforestry systems, the study investigates the fundamental capitals of the farmers and analyzes their access to livelihood capitals (Shahabaz 2009). Therefore, the study's assessment of rural farmers' subsistence used DFID's livelihood framework.

III. RESEARCH METHODOLOGY

3.1 The practices of recognized agroforestry

3.1.1 Acacia-Pineapple-Papaya-based agroforestry practice: Practice of agroforestry centered on Acacia, Pineapple, and Papaya is widespread and used frequently in the Madhupur Garh region. A donor-funded effort introduced the Acacia tree to Madhupur Garh in 1989, bringing a commercial wood species from Papua New Guinea/Australia (Islam et al. 2011, 2012). Since the acacia (Acacia auriculiformis) grows quickly, farmers frequently scatter acacia trees along farmland boundaries or inside the cropland itself. The number of Acacia trees per hectare varies depending on the individual farmer's preference. Because of its deep roots and straight canopy, the acacia often has less competition from other crops for water, light, and nutrients. The farmers periodically gather and sell firewood and timber from acacia trees. The Acacia may be planted in poor soil and can quickly sprout from seeds. According to the study, farmers in Madhupur transplanted pineapple suckers line to line (30 to 40 cm apart) and sparingly mixed papaya into the pineapple rows together with Acacia trees. In this way, over 24,000 pineapples and 2,000 papaya were transplanted. Up to ten years may pass before the Acacia-Pineapple-Papaya agroforestry systems are finished. Acacia trees would be harvested and put on the market after ten years, while pineapples continue to

translate for up to four years, with yields beginning at 18 months. The papaya tree typically yielded well for two to three years, and farmers often see their maximum economic returns in the second year of agroforestry.

3.1.2 Acacia-Pineapple-Ginger based agroforestry practice: The: Acacia-Pineapple-Ginger agroforestry practice is also widely used in Madhupur Garh. The acacia trees were planted as before, but this time ginger was put between the two rows of pineapple crops rather than in between them. Approximately 20,000 pineapples and 600 kg (17 mounds) of ginger were transplanted per hectare of land during this method. A plant that has been used in this area for a very long period is ginger. Typically, shade-loving agroforestry crops like ginger can be grown there with good yields thanks to the soil types and temperature of the Madhupur Tract (Safa, 2004). The agroforestry method typically lasts for ten years, after which the acacia tree is cut and a new plantation is planted to restart the operation.

3.1.3 Acacia-Pineapple-Turmeric-based agroforestry practice: The Acacia, Pineapple, and Turmeric practice is also widely used in Madhupur Garh. Acacia trees are planted along with pineapples, turmeric, and ginger by the same farmers. The only variable in this method was the quantity of turmeric seeds used; 165 kg of turmeric seeds are needed for 1 hectare of land. Because it is a seasonal crop, turmeric is taken out of the ground before pineapples ripen. As a result, the farmer can earn some money to start growing turmeric alongside acacia and pineapple. The entire production cycle lasts for ten years, during which time all acacia trees are harvested.

3.1.4 Mango-Pineapple-Papaya-based agroforestry practice: In the Madhupur Sal forest area, this agroforestry method is fairly frequent and well-liked. Mango (Mangifera indica) trees are a commercial fruit species that have lately been grown in this area. Different crops were planted beside the mango trees, which were dispersedly growing both inside the cropland and around its perimeter. As a deep-rooted and heavily branching tree species that supports a canopy, the mango typically has few competitions from nearby crops for water, light, and nutrients. The majority of farmers in Madhupur Garh grew the Amropali kind of mango, which generates more cash for growers than any other crop. The farmers occasionally harvest and sell fruit, wood, and firewood from the mango trees. The mango saplings are also easily accessible in the neighborhood. The study found that when the practice of agroforestry first began, ethnic farmers were growing papaya, pineapple, and pineapple in conjunction with mango trees. Around 300 mango trees were transplanted per ha, and 250 papaya plants and 18,000 pineapple plants were established alongside the existing mango trees. The agroforestry systems of mango, pineapple, and papaya may be maintained for another 5 to 7 years before being converted into a mango orchard.

3.1.5 Acacia-Pineapple-Aroid-based agroforestry practice: The Acacia-Pineapple-Aroid practice is one of the most popular practices all around Madhupur Garh. Aroids of many sorts were seen in the study area, but the Ponchomukhi Kochu (Colocasia esculenta) variety, which is indigenous to the region, thrived in the shadow in the Madhupur soil tract. Aroid is particularly nutrient-dense and required lower production costs, meaning that productivity was higher and input costs were very low. Aroid could be grown easily alongside Acacia and Pineapple crops by the farmer. Here, the Aroid was moved between the pineapple rows, and it would take about 450 kg of seed and 20,000 pineapple suckers, together with 400 Acacia trees, to cover the one ha of ground. For aroid crops, the intercultural activities were also kept to a minimum, and all other operations followed the same guidelines as other agroforestry techniques used in this region.

3.2 Study Location

Eight villages in Bangladesh's Tangail district, including Gaira, Sholakuri, Joynagacha, Bhutia, Dhukola, Auronkhola, Magontinagar, and Beribaid, were used for the study. Temperatures in this region range from 10-34°C, and annual rainfall is between 203-229 cm.

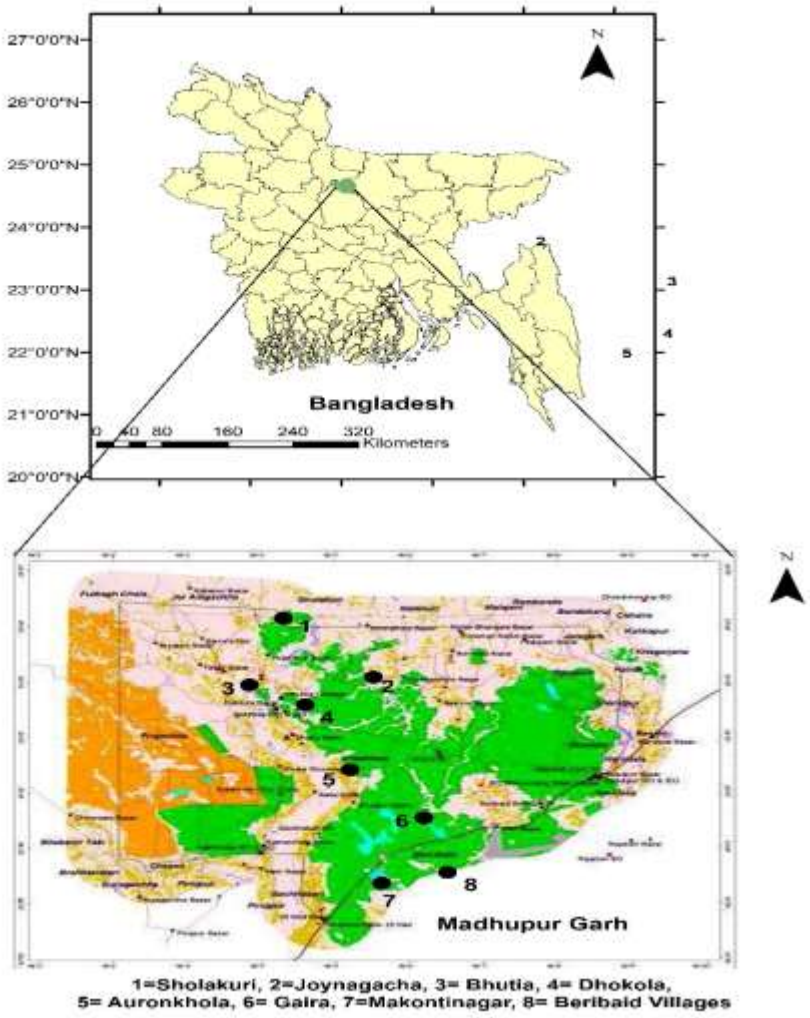

Fig.1: Study area map showing the selected villages of Madhupur Garh.

Highly oxidized reddish-brown clay soil with moderate to strong acidic responses characterizes the region's soils. Low levels of organic matter and fertility are further traits of the soils

3.3 Sampling and Information Gathering

Prior to gathering data, the study's information came from agroforestry farmers who had a casual conversation with the Madhupur Garh's ethnic population. Focus groups and interviews with households were used to get the preliminary data. For the survey of ethnic farmers' households, the study randomly selected 50 ethnic farmers from among the eight communities. For more than five years, the selected ethnic farmers engaged in potential agroforestry on their properties. The interview was conducted using a questionnaire survey that included questions about the socioeconomic status of ethnic farmers, their income from agroforestry, the improvement of five capitals of livelihood through agroforestry methods, and the challenges faced by ethnic farmers in the research area. Focus groups were conducted as part of the study in addition to the household interview.The focus group discussion was explained to the ethnic farmers, and accurate notes were taken of their opinions. In order to ensure that the information was accurate, conservation efforts with ethnic farmers were repeated in each common and decision-making scenario. The entire data gathering period was from March to September 2020, and at the conclusion of the study, the acquired data were verified, cross-checked, and confirmed.

3.4 Analysis of Data

The identified agroforestry techniques produced a variety of agricultural and forestry products. The crop output that was produced alongside trees was gathered for the study and converted to hectares. Wood, firewood, fruits, and other non-timber product revenue were computed on the basis of the year per hectare, much like crop production. All of the goods' profits were determined using the current mean market price of rice in Bangladeshi Taka (1 USD = 84 Taka). The study also showed how to calculate the Benefit-expense Ratio (BCR), which measures the rate of return per unit expense for the specified agroforestry practices:

BCR = $\frac{\sum_{t=0}^{n}\frac{B_t}{(1+r)}}{\sum_{t=0}^{n}\frac{C_t}{(1+r)}}$ here, B_t= gross benefit in i^{th} year, C_t= total cost in i^{th} year, t= number of year and i= interest (discount) rate (assuming 11% interest rate). Finally, the obtained data were tabulated and analyzed with the help of Microsoft Excel.

IV. RESULTS AND DISCUSSIONS

Demographic Characteristics of the Farmers

According to the study, farmer families' average sizes were larger than 0.36 per hectare and there was little variation in their length among the eight villages (Table 1). The participants were 41 years of age on average (Table 1). A few of the eight villages had male to female ratios that were nearly equal in some of the respondent's families. The farmers of Auronkhola have a significantly greater charge (60 percent) for literacy (Table 1).

The participants' original religion was converted to Christianity. Table 1 shows that household landholdings have increased to 0.36 ha, with agriculture serving as the primary source of income for the majority of people.

Table 1: Demographic features of the respondents

Features	Sholakuri	Joynagacha	Bhutia	Dhokola	Auron-khola	Gaira	Makonti nagar	Beribaid
Age (Mean)	44.4	40.5	42.6	39.5	40.4	38.8	46.36	42.30
Male: female ratio (Mean)	3:4	5:6	4:5	5:4	3:4	4:5	3:4	5:6
Literacy rate	40	55	50	45	60	40	50	45
Per household land holding(ha) (Mean)	0.30	0.24	0.24	0.42	0.30	0.36	0.24	0.42
Source of main income*								
-Agriculture	70%	65%	60%	50%	60%	75%	65%	60%
-wage labor	20%	15%	15%	20%	25%	10%	15%	20%
-Buisness	5%	10%	25%	20%	15%	10%	10%	10%
-Unemployment	0%	5%	0%	5%	0%	5%	5%	5%
-Remittance	5%	5%	0%	5%	0%	0%	5%	5%

Return on Investment from Known Agroforestry Practices

The financial advantages of tree-crop-based agroforestry significantly contribute to the household income of Bangladeshi farmers in rural areas. The implementation of the suggested agroforestry method in eight communities enhanced the living conditions of the ethnic farmers in the study area. Economic analysis showed that crop income is the main factor influencing the outputs of agroforestry practices (Table 2). The agroforestry method demands a lot of labor, which was formerly thought to be the main cost of production. Due to their ability to grow from seeds, farmers did not have to pay a higher price to buy and place the tree on their fields. The average yield of the various production systems is shown in Table 2 along with the overall production costs.

Table 2: Cost of production,total income and net income of agroforestry practices in hectare per year

Itemes of operation	Acacia-Pineapple-Papaya (TK)	Acacia-Pineapple-Ginger (TK)	Acacia-Pineapple-Turmeric (TK)	Mango-Pineapple-Papaya (TK)	Acacia-Pineapple-Aroid
Tree seedlings costs	19750	17600	18000	21325	18400
Land preparation costs	15425	16200	16820	19326	10840

Crop seedlings/rhizome/sucker buying costs	28500	31366	29650	27658	26725
Labour costs	54575	68180	62328	64340	43750
Fertilizer and manure costs	26450	27745	21325	17458	13450
Insecticides and pesticide costs	6575	7790	19750	22340	6445
Weeding and Irrigation costs	9525	12375	11240	13445	13450
Harvesting costs	25375	33425	26680	26435	24450
Sticks	8400	5700	8500	9650	5825
Transport	1000	750	672	860	950
Miscellaneous	8750	14325	12436	14325	9450
Timber income*	45000	41000	43000	48000	44000
Thinning tree income	8000	7000	5000	6000	9000
Firewood income	2900	2500	2200	2500	2000
Fodder income	700	900	500	400	800
Crop income	410500	616500	385400	455200	470617
Total Gross income	467100	667900	436100	512100	526417
Total production cost	204325	235456	227401	237162	173735
Net income	**262775**	**432444**	**208699**	**274938**	**352682**
BCR	**2.29**	**2.83**	**1.92**	**2.16**	**3.03**

*Total income of trees was calculated on the yearly basis

It is evident that farmers planted a variety of crops beside a variety of trees and made significant profits (410500, 616500, 385400, 455200, and 470617 Taka, respectively) (Table 2). The tree provided income in the form of feed, firewood, lumber, and thinning. A common economic statistic that takes into account both the costs and returns of both components is the benefit-cost ratio (BCR). The BCR value of the tree-crop-based agroforestry approach in the regions was 3.03, which is quite good.

The study found that the tree species on agroforestry farmers' agricultural holdings, which provide them with a vital source of income, strengthen their resilience. The outputs of the production system, such as lumber, firewood, thinning, feed, and other non-timber items, acted as a safety net against income risks in the event of crop failure (Avelino et al. 2011; Branca et al. 2011). The outcomes of the agroforestry practice also showed that farmers have a year-round source of income, and the systems' benefit-to-cost ratio was significantly higher than that of the nation's traditional agriculture systems (Islam 2019).

4.1 Improvement of Livelihood

Agroforestry based on tree crops has been used by ethnically poor farmers to maintain their way of life. As a result of their involvement in the program, they were able to accumulate a variety of livelihood capitals; this study examines some of these capitals' most important components (DFID 2001; Islam et al. 2012a, 2012b; 2011). To familiarize themselves with scientific training on agroforestry, a small number of training sessions and workshops were held by local NGOs and GOs (17%) (Table 2). However, in order to operate the chosen agroforestry systems effectively, specific knowledge will be required, therefore training farmers in the suitable manner will not be sufficient. As a result, the vast majority of ethnic farmers conducted their production techniques using knowledge passed down from their parents and grandparents. Farmers' literacy rates among the participants showed a slight improvement (47.5%). (Table 2). Respondents stated that, in order to make a better livelihood, the participants' families' labor pool had risen marginally. The family members' ability to feed themselves throughout the year

after being part in the agroforestry system was found to be highly beneficial and improved. However, Madhupur Garh's underprivileged population has limited access to medical care. Metropolitan areas in Bangladesh have a greater coverage rate for the government health program (Islam et al. 2012). The participants went to a nearby clinic or hospital for treatment because it was determined that they could manage their family's healthcare system. Because of the money that agroforestry systems brought in, farmers were able to visit the forest. A municipal hospital or a private clinic was cited by participants. Therefore, although there has been improvement, it has not been sufficient and there is still opportunity for growth in the farmers' human capital. The definition of "social capital" is a subject of considerable debate (DFID 2001). According to Dersham and Gzirishvili (1998) and Moser (1998), social capital is a system of interconnected assistance that people may draw from for a variety of needs, including loans, child care, food, housing, and information about opportunities. In addition, social capital is a substantial and essential resource for the poor, particularly during times of crisis and socioeconomic change (Islam et al. 2012). The study found that while agroforestry producers were able to establish close relationships with other agroforestry farmers in the neighborhood, these relationships were strained with the neighborhood's elite and leaders. Additionally, the farmers' Agriculture officers interacted with them just minimally. Even though agroforestry techniques have a long history and are widely used production tactics, ethnic farmers in Madhupur Garh, Bangladesh, have developed strong social ties and self-confidence. The establishment of social assets is dependent on the institutions, attitudes, and values that govern participant interactions and contribute to economic and social development, despite the fact that social relationships and networks are personal characteristics in a social context, and the overall social assets of agroforestry farmers are improving (Table 2). According to DFID (2001), "natural capital" refers to the natural resources and services that support people's livelihoods. It includes natural resources that are unrestricted (open access), such as woods, water, and grazing land, as well as environmental assets like land and common property resources (Islam et al. 2012). The respondents were categorized as landless (having 0 to 0.2 ha land), marginal (having 0.2 to 0.6 ha land), small (0.61 to 1.0 ha), medium (1.0 to 2.0 ha), or large (>2.0 ha) farmers based on the size of their farms (Iqbal 2007). The participants were tiny farmers (Table 2) due to their smaller homeland (0.62 hectares) (Table 2). In this study, the perceptions of farmers toward the environment were examined. Each farmer has a healthy quantity of trees on their farmland (about 85 trees per hectare), and maintaining trees has several advantages. Fruit trees were planted by farmers because they understood the value of keeping and maintaining green cover in their homestead locations. A typical farmer's property has 30 distinct tree species, which offer their family a variety of foods and nutritious sources. Because of this, agroforestry systems were steadily improving the situation and their natural capital.

Table 2. State of major characteristics of the participants in the community.

Parameters	Status	Trends
Farmers Literacy rate	47.5%	Improving slowly
Children literacy rate	78%	Improving sharply
Involvement in social organizations	>8	Increasing
NGOs and GOs	>17	Increasing
Micro-credit and easy loan facilities	Good	Increase Microcredit/easy loan
Farmers received scientific training on agroforestry	72%	Satisfactory
Belief and norms progress	84%	Satisfactory
Farmers social relationship with other stakeholders of the community	Moderate	Improving gradually
Women employment	90%	Increasing
Household infrastructure and physical assets	Concrete-wall and tin- roof, shift from mud-wall and sun-grass roof	Increasing physical assets
Electricity facility	Rural electricity and mostly solar electricity	Improving gradually
Road infrastructure to farm and markets	Brick and bitumen seal	Improving

Livestock small (e.g., chicken)	2.8	Increasing
Livestock big (e.g., cow, goat)	0.9	Slightly improving
Available of labor in the households	96%	Slightly increasing
Alternative market facilities to sell agroforestry products	2.0	No change
Food sufficiency of the household members throughout the year	11 months	Increasing
Annual expenditure	91.2%	Slightly improving
Local Clinic and Hospital facilities for farmers	1.5	not changing but small clinics increasing in the village market area
Tree stock in household premises	60%	Improving gradually
Tree stock in AF system	70	Not changing
Watersheds cover	92%	Satisfactory
Alternative livelihood options	Exist	Increasing

Infrastructure and producer goods needed to support livelihoods are referred to as physical capital. Assets include things like a place to live, furnishings they own, rent, or use, and access to public infrastructure (DFID 2001). Since housing is used for both shelter and reproduction as well as productive or income-generating functions (such as renting out rooms or using the space as a workshop), it is typically one of the most valued assets in poor people's houses (Moser 1998). In Bangladesh's rural districts, homes with brick walls and tin roofs are increasingly common (Islam et al. 2012). More than 80% of the structures among the participants had tin roofs and concrete walls, with mud walls and sun-grass roofs in between. On the other hand, local road infrastructure was gradually improved, and mud roads eventually gave way to brick and bitumen-sealed roads (Table 2). Using the Participants in the agroforestry program were able to buy small and large livestock with the money they earned. Furthermore, just a small percentage of respondents said they used agroforestry revenues from sales of cellphones and televisions. Farmers renovated their homes repeatedly because they sold both small and huge animals for a lot of money. Therefore, the growth of ethnic farmers' tangible assets was a promising indicator for the future of their way of life.Financial capital refers to the resources that people use to achieve their aims for a living (DFID 2001). One of the most precious assets for ethnic farmers was typically the money they made from selling their labor. The two primary sources of financial capital are available stock (such as cash, bank deposits, or liquid assets) and a consistent flow of funds (such as remittances, pensions, and labor sales) (Islam et al. 2012). The study found that farmers have easy access to lending facilities and microcredit, and the participants were involved in numerous organizations to receive funds and technical assistance to manage a possible

agroforestry program. The entire tree and agricultural outputs of the ethnic farmers are their significant cash resources, which they can use to invest in their intangible, physical, and other assets. The results show that the management of agroforestry systems will greatly raise farmers' capital (Table 2). The study takes into account the difficulties that local ethnic farmers encountered when using agroforestry systems based on tree crops. More than 90% of the farmers said that the lack of current information and help from government agencies (such agriculture officers) were the top issues in their community. The absence of alternative market facilities and intermediary intervention, which would limit the farmers' capacity to profit from the sale of their agroforestry goods, was one of the main complaints voiced by the farmers. Aside from these problems, ethnic farmers have faced more minor ones like a shortage of pesticides and fertilizers at the neighborhood level. The research claims that these issues have impeded the systems' profitability and negatively impacted their way of life.

4.2 Social ties between the participants

In times of family difficulties and socioeconomic change, poor people require social connections and networks more than ever. The results show that agroforestry practice created a brand-new social platform with members arranged into a distinct social group. On a 5-point Likert scale (ranging from +2 strongly positive, +1 positive, 0 neutral, -1 negative, and -2 severely negative), the study discovered that the participants had a very positive relationship with one another (Figure 2). The study found that the FD's control of power over forestland user rights and

participatory forestry programs has caused distance with local participants, and local leaders support the FD in this regard. On the other hand, the participants had a negative relationship with the local FD and leaders.

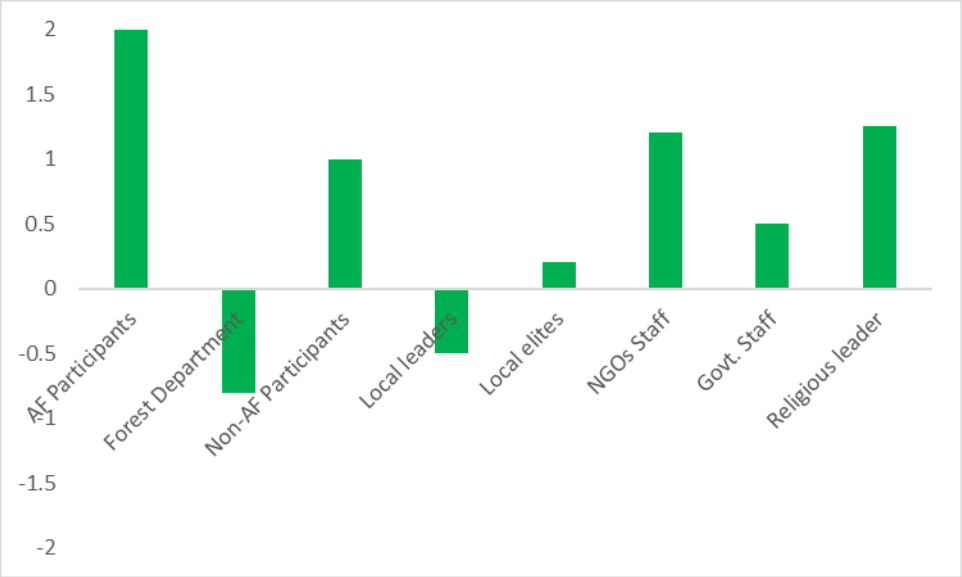

Fig.2: Social relationship of the participants in the community

V. DISCUSSIONS

Agroforestry models were executed to improve the livelihood of the local community. The economic analysis showed that all five models could generate income for the participants, of them, the Acacia-Pineapple-Ginger based agroforestry model produced the highest output of 432,444 Taka followed by Acacia-Pineapple-Aroid (352,682 TK), Mango-Pineapple-Papaya (274,938 TK), Acacia-Pineapple-Papaya (262,775 TK) and Acacia-Pineapple-Turmeric (208,699 TK) models respectively (Table 2). The outputs of tree income did not vary significantly as the total gross income of the agroforestry models depends on mainly crops income (Table 2). The production cost of crops was greater at the beginning of the program cycle or year 1 and two. Accordingly, the cost of seedlings or planting materials were much higher in the first year, however, the labor cost of all models was higher than other costs. The participants mentioned that the availability of the day labor was decreasing and their daily wage was increasing day by day in the Madhupur area. The cost occurred in the cultivation of 1 ha Mango-Pineapple-Papaya model was the highest (237,162 TK) and the Acacia-Pineapple-Aroid model was the lowest (173735 TK) (Table 2). To measure profitability, all cost occurred during the rotation period of 10-year and income from the sales of both tree and crops were assessed accordingly. The net profit of the different models showed that Acacia-Pineapple-Aroid is the most profitable agroforestry model in the study area as the market price of aroid did not vary, and the cost of production of this model was minimum. Moreover, the Benefit Cost Ratio is a common indicator of economic analysis as it takes into account both costs and returns of both components over the 10-year cycle of each agroforestry model. The results showed that the Acacia-Pineapple-Aroid was the most cost-effective model having the highest BCR (3.03) in the study area. Despite the highest BCR value of the Acacia-Pineapple-Aroid model, the farmers of the Madhupur area widely practiced the pineapple-based production model. Because, the pineapple provides return up to 5 to 6 years after initial plantation of pineapple crops, and a good pineapple marketing system has been built up in the Madhupur area. The participants also narrated that the price of crops like turmeric varies in the main season and often, farmers were not getting the suitable market price of their products because of oligopoly led by a few powerful businessmen.

VI. CONCLUSION

As a production system based on tree crops, agroforestry offers a number of benefits that can help ethnic farmers improve their standard of living and household income. The study's conclusions indicate that in order to maximize the farm's benefit-cost ratio, the chosen agroforestry method must boost farmers' overall household income. Farmers received a steady income throughout the year, and tree products also provided a backup in case crops failed due to unfavorable weather. The study also discovered that although the expansion of social and human capital had not been sufficient, the influence of tree-crop agroforestry had considerably improved the financial, physical, and natural

capital development of rural farmers. It is important to pay more attention to how agroforestry may support ethnic farmers in building their human and social capital. The productivity and results of the agroforestry system were also limited by the numerous difficulties faced by ethnic farmers. It is now necessary to build on the current social and human capital development of the farmers in Madhupur Garh, Bangladesh, by giving them training on scientific agroforestry production and strengthening their relationships with agriculture officials. The study concludes that agroforestry may be a more environmentally friendly style of land use if the government and other interested parties collaborate to assist ethnic farmers and find solutions to their production issues.

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